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Newsletter

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Spruce Budworms
Program

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This issue introduces a new "feature article" concept, the first of which follows. Publication henceforth will be at two month intervals.

The Eastern Spruce Budworm

The coniferous-feeding forms of the genus *Choristoneura* have a world-wide distribution in northern temperate zones. As forest pests, *Choristoneura murinana* (Hub.), is the most common representative in continental Europe, and *Choristoneura diversana* (Hub.) in Japan. There is little published literature on the genus in Asia. In North America 13 species have been identified to date feeding on firs, spruces, and pines. The two most common are the western spruce budworm, *C. occidentalis* (Freeman), and the eastern spruce budworm, *C. fumiferana* (Clemens). The eastern spruce budworm has the widest distribution ranging from the MacKenzie river watershed east to Newfoundland and south along the Atlantic coast to Virginia.

The adult eastern spruce budworm is a grey to reddish-brown moth with an indistinct pattern on the forewing and a wingspread ranging from 22 to 30 mm. In eastern North America adults are present from late June until early August depending on temperature. Adults live for about 2 weeks. The female generally emerges during the midafternoon, commences to attract a male (extrusion of the sex pheromone gland) and mates shortly thereafter. In cages, the bulk of the eggs are laid within 3 days after mating. In the field young females are relatively inactive; older females disperse over large distances, carried by prevailing winds.

Nonstarved females lay about 200 eggs, in masses averaging 20 eggs per mass. The number of eggs per mass and individual egg weight (initially about 0.18 mg) decrease during the oviposition period. The peripheral shoots in the upper crown levels of the taller trees in a stand are the preferred oviposition sites.

The eggs hatch in about 10 days and the first-instar larva (L1), which does not feed, searches for a suitable site (crevices of the bark, under bud and bark scales, and among lichens on the branches) to spin an overwintering shelter. During this period many L1 disperse to nonhost species. The bulk of the L1 population settles in the peripheral or 'outer shell' of the crown. The first molt takes place in September within the hibernation site, and larvae remain inactive until the following spring.

In late April — early May of the following spring the L2 leave the hibernacula and search for feeding sites among 1 year old needles, staminate flowers, or unopened vegetative buds. A second dispersal of small larvae occurs at this time.

In general, L2 leave the mined needles, buds and staminate flowers and move to the opening vegetative buds in late May and early June. They molt and begin feeding on the flaring shoots. However, on species such as red and black spruce whose shoots do not flare until later in the spring L3 sometimes construct 'open' feeding sites and continue feeding on old needles until new foliage becomes available.

The ultimate larva stage, L6, is present in the field about mid-June. The bulk of the feeding occurs at this stage. The mature larva is about 20 mm in length; the average male larva weighs 85 mg, the average female 120 mg. Pupation usually takes place in the feeding site of the sixth-instar larva. At very high densities, larvae may move inwards on the branch or drop to the understory to pupate. The pupal stage varies from 8 to 12 days. Pupal survival is generally high although birds and a complex of general parasites can cause 20 to 30 percent mortality at low to moderate densities.

There are three critical periods in the life cycle of the spruce budworm; 1) fall and spring dispersal of small larvae; 2) the age interval from L3 to L6; and 3) the adult stage. Survival of pupae is correlated with survival of large larvae but mortality is not as variable.

The greatest loss in absolute population numbers within a generation occurs during the dispersal of L1 in the fall and L2 in the spring when many larvae settle on nonhost species. For example, counts of egg masses in August and subsequent counts of feeding larvae (L3) at the same sampling point in the spring show survival rates ranging from 5 to 66 percent at moderately high infestation levels. The highest survival was recorded in a dense middle-aged stand of balsam fir with a closed crown canopy, little or no defoliation, and where some trees had begun to produce staminate flowers. Much lower survival rates were recorded in a stand of similar origin, age, composition, and tree density, except that the stand was within a budworm outbreak zone and defoliation was severe. Low survival rates have also been recorded in older, open growing stands where presumably crown closure was a critical factor.

Mortality may range from 40 to 90 percent during the age-interval from L3 to L6. Predators, parasites, birds, and pathogens take their toll of large budworm larvae, and their impact is particularly severe at very low budworm densities. The impact of parasites and pathogens is probably at a peak during the declining phases of an outbreak while predators, particularly birds, and certain specific parasites probably exert their maximum effectiveness during the intervening years between outbreaks when the mean L3 density per mature balsam fir tree probably ranges from 5 to 15 per tree in middle-aged balsam fir stands. At moderate population densities (5000 L3 per tree) natural control factors exert minimum mortality and populations quickly attain epidemic levels

of 15,000 L3 per tree. In general, this increase is curbed in a predominantly fir forest by the budworm itself which kills its available real estate. Budworm populations decline as tree mortality increases from 0 to 80 percent over a 5 year period in a unmanaged forest. In a budworm-prone forest the epidemic cycle lasts about 10 years.

The adult stage is the third critical period in the life cycle of the budworm, although the various factors affecting adults, particularly females, have not been individually defined. One method of assessing the combined effect of all factors on 'populations' of females, including dispersal, is to divide the observed number of eggs per unit area of foliage on a particular site by the number of female pupal cases counted on the site. This observed eggs per female (E/F ratio) can then be compared to the expected E/F of 200. Estimated E/F ratios based on broad-scale surveys range from 30 to 250 with the highest ratios being associated with significant increases in the size of an infestation. Thus the fate and dispersal of egg-carrying females are important factors in the dynamics of budworm populations.

Balsam fir is the preferred host of the eastern spruce budworm although it feeds heavily on red spruce, white spruce, and to a lesser extent on black spruce. At very high population levels it will spill over to hemlock and larch. In severe infestations it will kill branches in the upper crown levels of hemlock.

Data on the susceptibility to attack and vulnerability to damage of particular tree species and forest types are not easily acquired because few institutions are willing to set aside a forest for budworm research and to accept the almost certain loss of fiber. However, a number of studies have concluded that maturing balsam fir (40 plus years) in large continuous acreages is one of the most vulnerable forest types.

Red spruce is mainly distributed in southern Quebec, Maine, and the Atlantic regions and, among the spruces, its vulnerability to budworm attack is relatively high. Swaine et al (1924) state that in overmature fir-red spruce stands in northeastern New Brunswick, "practically all the commercial balsam fir and 40 to 60 percent of the red spruce were killed during the 1912-1920 outbreak, while mortality of white spruce and black spruce were generally low." The relatively high vulnerability of red spruce is not readily explained — it is phenotypically similar to black spruce (red-black hybrids are common) but far more vulnerable to damage.

White spruce would be ranked well below balsam fir and red spruce in a budworm vulnerability rating. In most conifer stands in the lower St. Lawrence, Maine, and Atlantic regions white spruce usually comprises less than 20 percent of a stand and does not suffer a higher rate of mortality. It is suspected that the low vulnerability rating of white spruce can be partly traced to two factors: (1) Early budbreak in the spring, fast shoot growth, and early maturation of the shoot. Thus, in terms of budworm — host tree phenotype, white spruce is at an advantage because damage to young shoots is less severe if growth is well advanced relative to the development of the budworm; (2) White spruce produces more current shoots per tree and larger shoots than balsam fir or red spruce. Thus, other things being equal, 'x' number of budworms would produce less stress on white spruce than on the other two species.

It is generally agreed that black spruce is relatively immune to severe budworm damage. Mortality is generally light in pure stands of black spruce, but when black spruce is intermixed with balsam fir, mortality may range from 40 to 50 percent in heavily attacked stands.

Budworm feeding damage and stress to infested trees is cumulative. Early in an outbreak injury consists of a partial loss of new foliage especially in the upper crown. (If the ratio of L4 larvae to current shoots on the tree is 1:2 the level of defoliation will be 80 percent or more). In succeeding years, as the infestation progresses and density increases, the typical injury within a season consists of the destruction of new vegetative buds before the needles flare, the complete destruction of the current shoots that do flare, and partial feeding on 1 and 2 year old shoots. Under such feeding pressure mortality of balsam fir in maturing stands usually begins after 3 - 5 successive annual defoliations, although the first trees to die are the young regeneration and suppressed trees because of heavy feeding from larvae that drop from the overstory.

Unmanaged spruce budworm outbreaks generally last from 10 to 15 years and collapse when a large part of the real estate in the central core of the epidemic is destroyed. In managed forests the general strategy has been to prevent this destruction by imposing a control factor (chemical insecticide) that kills budworm larvae, saves foliage, and minimizes tree mortality. In general this tactic has been successful in control operations in eastern North America.

Toxicity Of Nonylphenol To Fish

A recent report has provided evidence that nonylphenol, a solvent used in the product Matacil, was 10 times more toxic to juvenile salmon than aminocarb, the active ingredient in Matacil. Matacil, the insecticide planned for use both operationally and experimentally in New Brunswick, Newfoundland, Quebec and eastern U.S. in 1979, was selected because it gave better results than other materials tested during experimental trials in Newfoundland in 1977, and it has a much lower operational dosage rate than other insecticides.

Extensive field trials since 1969 have demonstrated that from an environmental toxicological standpoint Matacil is as ecologically acceptable as fenitrothion. Since registration of Matacil in Canada in 1973, 5 million hectares of Canadian forests have been treated without a single recorded case of serious environmental damage either to fish or other desirable components of the environment. Toxicity to fish would present a hazard only if Matacil was applied at approximately six times the recommended dosage rates. Residues in forest environments degrade at about the same rate as comparable current insecticides.

It is proposed to extensively evaluate and monitor any spraying with Matacil during 1979.

B.t. Advisory Group

On January 24 the CANUSA B.t. Advisory Group, chaired by O.N. Morris, Forest Pest Management Institute (FPMI), met in Fredericton, N.B. to review the Canadian Forestry Service (CFS) technical recommendations for the use of B.t. against the eastern spruce budworm. Members of the group present included M.M. Pelletier, Quebec Department of Lands and Forests; C.A. Miller, representing CANUSA (CANADA); D.M. Schmitt, representing D.G. Grimble, the CANUSA (U.S.) cochairman of the Advisory Group; and J.B. Dimond, University of Maine. J.R. Carrow, Ontario Ministry of Natural Resources, also a member of the advisory group, could not attend the meeting.

The outcome of this meeting was a CANUSA Technical Recommendations statement for the use of B.t. in 1979. This document, incorporating a few minor changes from the original CFS document, was distributed to all agencies that had indicated an intention of participating in the cooperative B.t. program. The document defines minimum standards for formulation selection, deposit specifications, quality control, and pre-and post-spray population assessments, yet it does not deter an investigator from gathering additional data.

As of date, agencies planning to use B.t. in 1979 include: Nova Scotia Department of Lands and Forests (6100 ha. - 15,000 acres), Newfoundland Department of Forestry and Agriculture (ca. 400 ha. - 1000 acres), Parks Canada, Winnipeg, Manitoba (ca. 160 ha. - 400 acres), Quebec Department of Lands and Forests (ca. 18,000 ha. - 45,000 acres), Ontario Ministry of Natural Resources (4450 ha. - 11,000 acres), Forest Pest Management Institute, CFS (ca. 500 ha. - 1200 acres), Forest Protection Ltd., New Brunswick (200 ha. - 500 acres), and Maine Forest Service (ca. 8100 ha. - 20,000 acres).

CANUSA Working Groups Meetings

CANUSA (Eastern U.S.) Program Management organized meetings for the purpose of forming working groups. The meetings were held during February 26 - March 2, 1979 at the Ramada Inn, Bangor, Maine. Approximately 75 persons attended these sessions, representing budworm researchers from the U.S. and Canada, forest landowners and resource management agencies. At each working group meeting, participants discussed the status of knowledge and research on the working group subject area and the research which should be funded by CANUSA to help meet CANUSA goals. Meeting summaries are being prepared and will be mailed soon to all participants.

The next meetings of these working groups are scheduled for the last week of October 1979.

Joint Policy And Program Council

The JPPC met in Ottawa, May 1. Items on the agenda included the CFS Task Force on Spruce Budworm Research in Eastern Canada, the USDA-FS Task Force on Application Technology, the joint Canada/U.S. advisory committee on the use of *Bacillus thuringiensis,* the spruce budworm sex pheromone program, and discussion of joint financing of programs.

Mr. Jean Noel Poulin, Deputy Minister, Department of Lands and Forests, Quebec becomes the new member to JPPC, succeeding Mr. H.M. Clarke, Deputy Minister, Department of Forestry and Agriculture, Newfoundland as chairman of the Eastern Spruce Budworm Council. The ESBC is a group of senior forestry officials from the eastern Canadian provinces who have joined forces for the purpose of sharing knowledge and experience of the spruce budworm, and who are studying and collaborating in programs related to various aspects of the spruce budworm.

International Inventory

Initial outputs from the CANUSA R&D Management Inventory have been distributed to the Program investigators who provided information on their activities, and to key Program Management offices in Canada and the United States. Of special interest are indices of study titles and investigators keyed to the activities in the draft Convergence Analysis of February 1978 (see CANUSA Newsletter No. 1). This should make it easy for any investigator or user group to get in touch with others of similar interests.

The present inventory contains 188 basic records of studies or projects on spruce budworms in Canada and the United States. We will update and expand the file as new studies come on line and are brought to our attention. We hope that all investigators, agencies, and institutions will realize the mutual benefits from having their efforts recognized in this fully coordinated international effort.

Investigators are reminded to complete the questionnaire that was attached to inventory information package. The comments from the investigators will allow us to improve the inventory and make it a useful information source on spruce budworms research.

For more information on the inventory contact Program Leaders Buckner or McKnight.

CANUSA Mailing List

CANUSA (Eastern U.S.) is still trying to improve and broaden their mailing list, to include all those interested in the SBW problem or the progress of the CANUSA Program. Anyone who would like to be placed on the mailing list should contact Program Manager Dan Schmitt, CANUSA-East, USDA Forest Service, 370 Reed Road, Broomall, Pennsylvania, 19008, telephone: (215) 596-1607.

Research Proposals

In August 1978, CANUSA (Eastern U.S.) solicited, from all interested budworm research people, prospectuses of research for possible funding by CANUSA during 1979 fiscal year. The response was excellent. From those who submitted prospectuses which promised to contribute to attainment of CANUSA goals, detailed proposals were requested. Each proposal was reviewed and evaluated by a panel of technical specialists who recommended to Program Management that it be accepted, rejected, or accepted after revision.

To date, 20 proposals have been accepted and the administrative paperwork necessary for release of funds has begun. We expect all funding to be completed by April 1, 1979.

Publications

From time to time we will list reports and publications that may be of interest to you. Please call to our attention other items that you think might be of interest to CANUSA Program participants.

Interested in defoliation and moisture stress in host trees? Ask for Research Note PNW-323 from Pacific Northwest Station, Box 3141, Portland, OR 97208: *Effect of defoliation by the Douglas-fir tussock moth on moisture stress in grand fir and subsequent attack by the fir engraver beetle.*

Involved in aerial application of insecticides? You may be interested in *Methods for sampling and assessing deposits of insecticidal sprays released over forests.* For sale by Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Here is a recent report on use of B.t. against spruce budworm: *BACILLUS THURINGIENSIS: Operational Project — Spruce Budworm in Maine in 1978.* Ask for Entomology Division Technical Report No. 11, 1978 from the Department of Conservation, Bureau of Forestry, Augusta, Maine.

Published by CANUSA-East *Ecological Impacts of Forest Insecticides: an annotated Bibliography* by Jonathan Bart and Laurie Hunter: prepared by New York Cooperative Wildlife Research Unit, Cornell University, Ithaca, N.Y. As long as supplies last, single copies are available from Program Manager, CANUSA-East, USDA Forest Service, 370 Reed Road, Broomall, Pennsylvania, 19008.

Copies also may be purchased from National Technical Information Service, U.S. Department Commerce, Springfield, Virginia, 22161.

NTIS Accession number PB 290952/AS
Paper Cover: $7.25
Microfiche: $3.00

Chuck's Back

Charles Buckner, Canadian Program Leader, who suffered a heart attack in early October has resumed his duties as CANUSA Program Leader — Canada. Our thanks to Charles A. Miller who acted as Program Leader during Chuck's absence.